BNL Response to the Five Questions in James Symons' Letter to T. Kirk of January 17, 2001

January 29, 2001

Question 1: "*What are the new research initiatives which are being proposed for your facility during the coming years? Are there any specific facility upgrades, which you are pursuing to enhance the competitiveness of your facility through the next decade?*"

The new RHIC facility had its first collisions during the summer of 2000. All four of the RHIC detector collaborations, comprising an international community of over 1000 physicists, have successfully begun gathering data, and after only a few months of analysis have already begun to have a profound impact on our understanding of the QCD structure of matter, with new results on high energy density phenomena in the most energetic nucleus-nucleus collisions yet achieved under laboratory conditions. RHIC is now positioned to move forward with the world-leading scientific program foreseen in the long range planning efforts of the past two decades. In addition, the necessary accelerator components to carry out the RHIC spin program are being put in place, and a first commissioning run has demonstrated the ability to store and control beams of polarized protons in the RHIC rings, utilizing the "Siberian snake" helical dipole magnets.

During the next five years, the main physics goals for RHIC are:

- discovery and characterization of the quark gluon plasma
- measurement of the gluon spin structure of the proton (ΔG)
- hard collisions and jet quenching in hot nuclear matter
- A-dependence of high energy nuclear collisions
- Quark transversity structure functions $\delta q(x,Q^2)$

The RHIC collider facility is unique in the world in its ability to carry out this program of research. The most important priority for the users of RHIC over the next several years is to realize the planned level of operation, 37 weeks per year, to fully exploit this long-sought physics capability, and reap the rewards of the substantial technical and intellectual investment in RHIC. During the next few years, as experience is gained with operation of the machine at its full design performance, the luminosity is expected to be improved by a factor of four over its design value. The means for this improvement in luminosity is already incorporated in the design of the collider, and no new construction funds are required to implement it. In the meantime, several moderate-scale upgrades to the existing RHIC detectors are planned over the next five years to further extend their physics capabilities as the exploration of this new energy regime moves forward. These upgrades are on the scale of the Additional Experimental Equipment (AEE) projects, which are now reaching completion.

It is anticipated that by 2005 RHIC will provide data demonstrating a transition to the quark-gluon plasma phase of strongly interacting matter. Such an achievement would stimulate the need for more detailed characterization of the structure of the deconfined phase, and the implications of chiral symmetry restoration, through rare and selective signals requiring upgrades to the present accelerator and detectors. An order-of-magnitude luminosity increase for collisions at RHIC, coupled with appropriate detector upgrades, would make it feasible to develop new probes of the temperature and parton composition of the QGP, based on the production of hadrons with multiple heavy quarks and on the electroweak production processes at a high mass scale. Other detector upgrades would be needed to improve background suppression for such QGP probes as open charm or low-mass dilepton production. RHIC has therefore included in the latter part of its decadal plan a major luminosity upgrade, the 'RHIC II' initiative, that will increase the luminosity of the machine by a factor of 10 using high energy electron cooling (52 MeV) of the circulating heavy ion beams and will also provide major upgrades to the RHIC detectors to allow them to take full physics advantage of this luminosity upgrade. A preparatory machine and detector technology R&D program in support of the RHIC II project is proposed for the period FY2002-2008. R&D support is planned to peak in the two years before the start of the RHIC II Project. Electron cooling R&D and its extension to 10 GeV electron beams will also be important to the successful evolution of the electron-ion collider concept being considered as part of the LRP process.

Question 2: *"The LRP Charge to NSAC explicitly asks us to consider the FY2001 Budget as the baseline budget for the field. Is this, in fact, a budget level which will allow your facility to operate in a lean, but competitive and cost effective manner, in the years to come? If not, what are the essential additional resources, which you would require, and the benefits that would accrue from them?"*

The FY2001 baseline budget will permit a workable RHIC program to run, but this program will be severely handicapped in scientific productivity and will poorly exploit the large capital investment DOE has already made in the brand new RHIC facility. A detailed, realistic analysis shows that full operation of RHIC for the planned 37 weeks per year will require an increase of \$15M from the present (2001) operating budget. This modification to the baseline will allow RHIC to operate in a lean but very effective manner and will allow the community to aggressively pursue the new RHIC physics as planned by the community and by NSAC.

To make our statement more quantitative, the \$103M per year FY2001 baseline scenario, if adopted on a 'constant effort' basis for future years, will provide at best only 24 operations weeks per year instead of the planned 37. Our ability to make even minimal capital improvements in the accelerator-collider complex and RHIC experiments will be severely restricted and the present understaffing of both the RHIC accelerator complex and the RHIC detectors support cadres will continue indefinitely. The physics output provided by this scenario will languish at about 25% or less of the optimized lean program characterized in the thrust of this question. In the baseline plus \$15M per year scenario, we will be able to run the long-planned 37 weeks per year RHIC program, the remaining shortcomings in the machine complex will be overcome in a few years and the detectors will continue on their planned steady improvement paths, thereby realizing the full physics research dividend promised to the heavy ion community with the construction of RHIC.

Question 3: *"What is the balance of your research program between work at your local facility and outside user efforts at other facilities in the US or abroad? Has this balance changed since the last LRP, and do you expect it to evolve further in the coming years?"*

The nuclear physics research staff of Brookhaven National Laboratory is overwhelmingly engaged in the RHIC and AGS experimental program and its associated theoretical nuclear physics efforts. The close experiment-theory collaboration in the heavy ion and polarized proton areas of research have provided important physics benefits to the BNL research program. The RHIC heavy ion physics program evolved directly out of the AGS heavy ion program which is now complete. There are a small number of nuclear physicists at BNL who work in the medium and low energy nuclear physics programs, about half in the LEGS experiment at BNL and half with the SNO experiment in Sudbury Canada. This balance has not changed significantly in the past few years. In the future, some BNL scientists may be attracted to the LHC heavy ion program but we feel that the RHIC facility will continue to be very productive in the LHC era and its scientific program will be more complementary than competitive with LHC heavy ion physics. In consequence, we anticipate that the overwhelming number of BNL researchers will focus on the RHIC program as it evolves toward higher luminosity and reaches the full physics opportunities presented by the relativistic heavy ion and spin physics fields of research.

Question 4: *"Are you satisfied with your ability to attract and support top quality graduate students?"*

The RHIC facility offers an extensive and rich menu of PhD reaearch topics for graduate students in nuclear physics and more than 80 thesis students have already been attracted to our university users groups as reported from a survey conducted last year. BNL itself does not offer a degree granting program. We cannot comment knowledgeably on the levels of support available to the university users of RHIC or whether this support is a serious damper on student recruitment.

Question 5: *"Are there other aspects of your facility and programs, which are unique or particularly noteworthy?"*

BNL is the home of the Riken BNL Research Center (RBRC), a new and very powerful center for theoretical and experimental research in heavy ion and high-energy proton spin physics headed by Nobelist T.D. Lee. This center, which presently has a scientific staff of 12 theoretical and 6 experimental physicists is almost entirely funded by the Riken Laboratory in Wako, Japan. BNL contributes space in the Physics Building and DOE has provided modest amounts of equipment funding to supply individual computer work stations for RBRC staff. The intellectual symbiosis between RBRC and BNL scientists, together with other university nuclear physics theory and experimental groups in the US has enabled very strong advances to be made to both RHIC spin and heavy ion physics topics, especially in theoretical physics. We believe, in fact, that the growing strength of BNL's nuclear theory group under Larry McLerran, combined with the RBRC theory cadre, represents possibly the strongest nuclear theory community in the world.

One especially significant aspect of the RBRC is its 'RHIC Fellows' program, under which eight participating physics departments currently share theory appointments with RBRC and have agreed to create permanent theory positions in RHIC-related physics. These new academic positions will be occupied either by the current RHIC fellow or by a successor faculty member. The number of RBRC RHIC fellows is planned to reach twelve in the near future.

We also note the technical contributions of BNL's renowned Instrumentation Division towards the introduction of new and unique instrumentation devices and systems. This division powers the continuous technical evolution of nuclear physics and many other science and technology research programs at the Laboratory and other venues worldwide. The uniquely creative output of this research and development center results directly from the freedom of inquiry provided by the direct funding support of the BNL director.